Numb. 63.

PHILOSOPHICAL TRANSACTIONS.

September 12. 1670.

The CONTENTS.

The Continuation of the Experiments concerning Reſpiration,*promiſed in the precedent Tract, and communicated by the ſame Noble Author,in* Ten *other Titles* ; viz. *Of the Accidents, that happen'd to Animals in Air, brought to a Conſiderable degree of Rarefaction ; To which is annex'd a digreſſive Experiment concerning Reſpiration upon very high Mountains. Of the Obſervations produced in an Animal by Changes as to Rarity and Denſity made in the* ſelf-ſame *Air. Of an unſucceſsfull Attempt,to prevent the* Neceſſity *of Reſpiration by the Production of Growth of Animals in the* Vacuum Boylianum ; *together with two digreſſive Experiments concerning the Expanſion of Bloud, and other Animal juyces, as alſo other ſoft parts,even in cold Animals. Of the power of* Aſſuefaction *to enable Animals to hold out in Air, by rarefaction made unfit for Reſpiration. Some Experiments ſhewing, that Air, become unfit for Reſpiration, may retain its wonted Preſſure. Of the uſe of the Air to elevate the* Steams *of Bodies. Of the long continuance of a* Slow-worm *and a* Leech *alive in the* Vacuum. *Of what happen'd to ſome* Creeping Inſects ; *and of the Phænomena ſuggeſted by* Winged Inſects, *in the ſame. Of the* Neceſſity *of Air to the motion of ſuch ſmall creatures,as* Ants,*and even* Mites *themſelves. An Accompt of two Books* : I. *TRACTS written by the Honourable* Rob. Boyle, *concerning* Coſmical *Qualities* ; Subterraneal *and* Submarine *Regions* ; *the* Bottom *of the* Sea ; *together with an Introduction to the Hiſtory of* particular *Qualities.* II. *CATALOGUS PLANTARUM ANGLIÆ, operâ* Johannis Raji. *M.A. è Soc. Regia.*

A Preface concerning theſe Experiments.

Though,to ſhun prolixity,the Preface,*which the Author had made to all he wrote about* Reſpiration,*have been purpoſely omitted ; yet there are ſome few points ſo neceſſary to be taken notice of,that 'tis thought unfit to leave them* wholy *untouch'd. For, the following Experiments being not at firſt written for the Preſs,and thrown by for many years,till they were very haſtily gather'd together,and in ſome places ſupply'd with others, little leſs haſtily annex'd to make ſome neceſſary ſupplys,the* Reader *muſt not expect in ſuch a Caſuall* Tract *(which the Author confeſſes to be one of the moſt imperfect and immethodicall of all his compoſures) any thing but Novelty,and Truth,and an Earneſt deſire to be ſerviceable in an Inquiry ſo important to Mankind, to the Curious in general,and eſpecially to Phyſitians, who by the incouraging mention they have made of his former endeavours in this kind,have invited him to add theſe many new Experiments to thoſe few,they had hitherto exerciſed their Wits upon ; And,to leave them the more freedom to do ſo,he purpoſely forbore to confirm,or confute any* Hypotheſis,*or ſo much as propoſe any of his own;declaring it to be his Aime,not to eſpouſe or make a party,but to communicate to the Curious ſome* matters of fact,*that are new ; and in an hiſtorical way impartially delivered. No more of* Preface *is now to be added, but that 'tis thought fit, for prevention of Ambiguity, to give this Advertiſement touching the ground of the Title of* Vacuum Boylianum, *to be met with in theſe Experiments ; That as Learned men,both Engliſh and Forreigners, in their writings have familiarly for diſtinction ſake imploy'd the Titles of* Machina Boyliana,*and* Experimenta Boyliana; *ſo the* Author,*that writ theſe,for the moſt part in haſt,and for his own memory,did,for diſpatch ſake,call the abſence of the Air procured in his Receivers,*our Vacuum ; *whence by Analogy was fram'd the* Vacuum Boylianum,*which he therefore thinks the leſs improper, becauſe to call it* Vacuum *abſolutely,would be judged by many a declaring himſelf a* Vacuiſt,*who does not yet own the being either of* their *opinion,or a downright* Pleniſt ; *or elſe he muſt be troubleſome to the Reader and himſelf,by frequently explaining, what ſort of* Vacuum *he underſtands ; whereas he declares once for all, that by the* Vacuum Boylianum *he means ſuch a Vacuity or Abſence of Common Air,as is wont to be effected or produc'd in the operations of the* Machina Boyliana.

X The

The Royal Society is collaborating with JSTOR to digitize, preserve, and extend access to *Philosophical Transactions (1665-1678).*
www.jstor.org

The XI. Title.

Of the Accidents that happen'd to Animals in Air brought to a conſiderable degree, but not near the utmoſt one, of Rarefaction.

IN the Generality of our Pneumatical Experiments upon Animals, it ſuited with our purpoſes, to rarifie the Air as much, and for the moſt part as faſt, as we could ; but I had other Tryals in Deſign, wherein an extraordinary degree of Rarefaction, but yet not near the higheſt to which the Air might be brought by our Engin, ſeem'd likelieſt to conduce to my inquiries, and particularly ſeem'd hopefull to afford ſome light in reference to thoſe Diſeaſes and Diſtempers, that are thought primarily to affect the Reſpiratory Organs, or to depend upon ſomething amiſs in Reſpiration.

Wherefore having *Gages*, by the help of which ſuch Experiments might be much better perform'd then elſe they could, I attempted ſeveral of them ; ſome of whoſe ſucceſſes I find in the following Memorials.

Experiment 1.

Auguſt 16th.

A *Linote* being put into a Receiver, capable to hold about 4½ pints of water, the Glaſs was well clos'd with Cement and a Cover ; but none of the Air was drawn out with the Engine, or otherwiſe. And though no new Air was let in, nor any change made in the impriſon'd Air ; yet the Bird continu'd there 3 hours without any apparent approach to death : And though it ſeem'd ſomewhat ſick, yet being afterwards taken out, it recover'd and liv'd ſeveral hours.

Experiment 2.

Auguſt 18th.

From the abovemention'd Receiver about half the Air was drawn out, a *Linote* being then in the Glaſs, and in that rarify'd Air (which appear'd by a *Gage* to continue in that ſtate) the Bird liv'd an hour and near a quarter before it ſeem'd in danger of death ; after which the Air being let in without taking off the Receiver, ſhe manifeſtly recover'd, and leap'd againſt the ſide of the Glaſs ; being taken out into the open Air ſhe flew out of my hand to a pretty diſtance.

Experiment 3.

Septemb. 9th.

We convey'd into a Receiver, capable to hold about 4½ pints of water, a *Larke*, together with the *Gage*, by the help whereof we pump'd out of the Receiver ¼ of the Air that was in it before ; then heedfully obſerving the Bird, we perceived it to pant very much, ſo that a Learned Phyſitian (from whom I yet diſſented,) judg'd thoſe beatings to be Convulſive : Having continu'd thus for a little above a minute and a half ; the Bird fell into a true convulſive Motion, that caſt it upon the back. And although we made great haſt to let in the Air ; yet before the Expiration of the Second minute, and conſequently in leſs than half a minute from the time immediately preceding the Convulſion, the Lark was gone paſt all recovery, though divers means were us'd to effect it.

Experiment 4.

Septemb. 9th.

Preſently after we put into the ſame Receiver a *Greenfinch*,and having withdrawn the Air till it appear'd by the Gage there remain'd but half, we preſently began to obſerve the Bird,and took notice, that, within a minute after,ſhe appear'd to be very ſick, and ſhaking her head, threw againſt the inſide of the Glaſs a certain ſubſtance which I took to be Vomit,and which afterwards appear'd ſo; upon this Evacuation the Bird ſeem'd to recover, and continue pretty well (but not without panting) till about the end of the fourth Minute,at which growing very ſick, ſhe Vomited again (ſhaking her head as at firſt,)but much more unqueſtionably then before,and ſoon after,eat up again a little of her Vomit; at which time (whether that contributed to her Recovery or no) ſhe very much recovered. And tho ſhe had,in all,three fits of Vomiting; yet for the laſt ſeven or eight minutes that we kept her in the Receiver, ſhe ſeem'd to be much more lively then was expected: which may in part be attributed to a little Air that by an accident got in, tho it were immediately pump'd out again. At the end of a full quarter of an hour from the firſt Exhauſtion of the Receiver,the Bird appearing not likely to dye in a great while,and the Engine being needed for other Uſes, we took out the Bird and thereby put a period to the Experiment.

Experiment 5.

I now thought it fit to try.Whether,though a Viper would not hold out very many hours in Air brought to as high a Rarefaction, as we could bring it by our Engin,yet to that cold and vivacious Animal, a very ſmall proportion of Air, in compariſon of what was neceſſary to hot Animals,would not ſuffice to keep it alive for a conſiderable time: The Narration of the Experiment I find regiſtred as follows.

*April.*12th.

A Viper lately bought of the perſon, that at this ſeaſon uſes to take new ones,almoſt from day to day, was included together with a Gage in a portable Receiver,capable to hold about 3½ pints of water. This veſſel being exhauſted,and ſecured againſt the regreſs of the Air,the impriſoned Animal was obſerved from time to time; and obſerved not only to be alive, but nimbly to put out and to draw back its tongue about 36 hours after it was firſt ſhut up; for which reaſon we continued the Veſſel longer in the ſame ſhady place; where at the end of 60 hours looking upon her,as I was going to bed, ſhe appeared very dull and faint,and not likely to live much longer: And the next morning being by ſome occaſions carried abroad, and coming to look upon the Glaſs preſently after dinner, I found her ſtark dead with her mouth open'd to a ſtrange wideneſs; wherefore ſuffering water to be impelled by the outward Air into the cavity of the Receiver, to obſerve how far that veſſel was then emptied of Air,we found by the water that was driven in,and afterwards poured out again and meaſured, that 4 parts of 5, or rather 5 of 6 of the veſſel'd Air(if I may ſo call that which was ſhut up in the Receiver) had been pump'd out: So that in an

Air ſo rarify'd as to expand it ſelf to 5 or 6 times its former and uſual dimenſions,our Viper was able to live 60 hours, that we are ſure of,and perhaps might a pretty while longer.

A digreſſive Experiment Concerning Reſpiration upon very high Mountains.

TO illuſtrate what I have taken notice of in the Printed Experiments about the unfitneſs for Reſpiration,obſerv'd by the learned *Acoſta* in the high mountains of *Pariacaca*,I ſhall here add, what I have had the curioſity and occaſion to learn from divers Travellers , whom I purpoſely conſulted about theſe matters ; whereof you will eaſily believe that not many of them have had opportunity to give Accounts.Meeting with an Eccleſiaſtical Perſon that had viſited thoſe high mountains of *Armenia*,(on one of which,becauſe of their height,the Tradition of the Natives will needs have the *Ark* to have reſted ;) I ask'd him, whether thoſe Mountains are really ſo high as is given out, and whether at the top of that he viſited he found any difficulty of *Breathing*. To the *firſt* part of which Queſtion he anſwer'd ; That they were really exceeding high (which he might well judge of, having been upon ſome of the moſt famous both in *Europe*,*Aſia*,and *Africa* ;) and that he could not come to the top,becauſe of the unpaſſable ſnows: And to the *ſecond* part he reply'd, that whileſt he was in the upper part of the Mountain he plainly perceiv'd,that he was reduc'd to fetch his breath much oftner than he was wont,and than he did before he aſcended the Hill, and after he came down from it. And upon my inquiring,whether or no that difficulty of breathing might not be accidental,or peculiar to him, he told me that he himſelf having expreſt ſome wonder to find himſelf ſo ſhort-winded,the people told him that 'twas no more than happen'd to them when they were ſo high above the plain ; it being a common obſervation among them. And I was the more inclin'd both to make inquiry about theſe matters ; and to believe what he ſaid, becauſe what he related of their being cover'd with ſnow, and of an odd Temperature of Air, I had learn'd before from a Travailer of another Nation than this Perſon,and a ſtranger to him.

The ſame Churchman,being ask'd by me,Whether he had not in ſome part of *Europe* made the like obſervation (of the difficulty of breathing) told me,that he had done it upon the Top of a Mountain in the Country of *Seuenes* in or near the Province of *Languedoc* ; which may ſerve to confirm what I am about to relate from the mouth of a Learned Travailer,that was upon the Top of one of the *Pyreneans* that is not very remote from the Mountains we ſpeak of.

This Gentleman,who was a perſon Curious and Intelligent, being Brother in Law to one of the chief Lords of thoſe parts, was by him invited,about the beginning of *September* to viſit a neighbouring Mountain, that is at leaſt one of the higheſt of the *Pyreneans*, which is commonly called *Pic de Midi*,upon whoſe Top,(where a Tent was ſpread for them) they ſtay'd many hours. His Anſwers to the other Queſtions I asked him,are elſewhere related : All that concerns this place being that

I find this ſet down among my Adverſaria ; *viz.*[I alſo inquired of him whether they found the Air at the Top as fit for Reſpiration as Common Air,which he told me they did not, but were fain to breath ſhorter,and oftner than uſuall ; and becauſe I ſuſpected , that might come from their motion,I ask'd,whether they obſerv'd it to ceaſe, when they came down to the Bottom of the Hill,which he told me they plainly did, beſides that they ſtay'd many hours at the Top,too long to continue out of Breath.

But that I may not here conceal any thing, that may conduce to the Diſcovery of the truth in the matter under conſideration, I ſhall here add,that I did ſometimes think it worth further Inquiry, Whether the Sickneſs,if not alſo the Difficulty of breathing,that ſome have been obnoxious to in the uppermoſt parts of *Pariacacha,* and perhaps ſome other high Mountains, may not be imputed not ſo preciſely to the Thinneſs and Rarity of the Air in places ſo remote from the lowermoſt part of the Atmoſphere,as to exclude certain ſteams of a peculiar nature, which in ſome places the Air may be imbued with ? In favour of which ſuſpition I remember,that inquiring once of an intelligent man , who had liv'd ſeveral years in the Iſland of *Teneriffe,*Whether he had been at the Top of the *Pic* of that name,and what he had there taken notice of about the Air ? He anſwer'd me,That he had attempted to go up to the Top of the Mountain,but that,though ſome of the Company were able to do ſo, he and ſome others,before they had reached near ſo high, grew ſo ſick upon the operation they felt of the ſharp Air,and Sulphureous exhalations which infected it,that they were fain to ſtay behind their Companions,he having already found this effect of thoſe piercing ſteams upon his face (which when he made me this relation,was of a fair complexion) that the skin began to be of a pale-yellow, and even his hair to be diſcolour'd.

The XII. Title.

Of the Obſervations produced in an Animal in Changes as to Rarity and Denſity made in the ſelf-ſame *Air.*

In the Experiments hitherto recited,the Animals that were recover'd from a gaſping Condition, have been ſo, by letting in freſh Air upon them,and not the ſame that had been withdrawn from them. Wherefore I thought it very requiſite to try, Whether the ſame portion of Air, without being renew'd,would,by being expanded much beyond its uſual degree,and reduc'd to it,ſerve to bring an Animal to Deaths door, and revive him again ; ſince by the ſucceſs of ſuch a Tryal,it would notably appear, that the bare change of the conſiſtence of the Air, as to Rarity and Denſity, may ſuffice to produce the abovementioned Effects.

But to deviſe a way to put this Experiment in practice appear'd no eaſy matter ; ſince it required a Receiver that ſhould be tranſparent, & be capable of changing its bulk without ſuffering any Air to get in or out.

To ſurmount theſe difficulties, the firſt thing I thought on was, to take a fine limber and clear Bladder of a ſheep or hogg, made more tranſparent by being anointed with Oyl, which was done on the outſide, that the ſmell of it might leſs offend the Animal to be included. Then we clipp'd off as much of the Bladder at the neck, as was judg'd abſolutely neceſſary to make an Orifice capable of letting in a *Mouſe*; that ſort of Animals being, by reaſon of their ſmallneſs, the fitteſt of thoſe furniſh'd with Lungs and hot blood, we conld procure. And whereas it ſeemed very difficult, when the neck of the bladder was cut off, to make up ſo large an orifice without wrinckles, at which the rarified Air may eſcape; to obviate this inconvenience, we provided a round ſtick ſomewhat leſs then the Orifice; that, the wood being laid over with a cloſe and yielding cement, (for, pitch or the like common ſtuff will not alwaies ſerve the turn) we might be able to tye the bladder faſt and cloſe enough upon the thus fitted ſtopple.

And now to reduce theſe things to practice, and by their help make our deſigned Experiment, we included a *Mouſe* into a Receiver made according to this way, leaving in the bladder as much Air, as we thought might ſuffice him for as long a time as the Experiment was to laſt. Then putting this limber or extenſible Receiver, if I may ſo call it, into an ordinary one of Glaſs, and placing this Engine near a window, that we may ſee through both of them; the Air was by degrees pumped out of the external Receiver, (as for diſtinction ſake I ſhall call it,) and thereupon the Air included in the bladder did proportionably expand it ſelf and ſo diſtend the external Receiver, till being arrived at a degree of Rarefaction, which rendred it unfit for the included Mouſes Reſpiration, I perceived, though with ſome difficulty, in this Animal the ſigns of his being in great danger of ſudden death. Whereupon the outward Air, being haſtily let into the external Receiver, compreſſed the ſwelled bladder to its former dimenſions, and thereby the included Air to its former denſity, by which means the fainting *Mouſe* was quickly revived. Having given him ſome convenient time of reſpite, the Experiment was reiterated with the like ſucceſs, and we doubted not but the third tryal, we made, would have ended as the two former did; but that, whileſt we were conſidering of the ſickneſs of the Mouſe, which, by reaſon of ſome opacity that could ſcarce be avoided in the wrinckled bladder, was not, as to its degree, ſo eaſily taken notice of, it grew irrecoverable by the ſubſequent condenſation of the Air.

N.B. The Confirmation of this by further Experiments will properly fall under another Title.

The XIII. Title.

Of an unſucceſsfull Attempt to prevent the neceſſity of Reſpiration by the Production *or* growth *of Animals in our Vacuum.*

Having had frequent occaſions to obſerve, how quickly thoſe Animals, whoſe Blood is actually warm, did expire in our *Vacuum*; and that even thoſe Animals with Lungs, whoſe Blood was actually cold, were not able to live any conſiderable time there; I thought it very well worth while, and yet extreamly difficult, to try, whether there might not be ſome wayes yet unpractiſed, either to make ſuch Animals as Nature endows with Lungs, live without Reſpiration, or at leaſt to bring ſuch *Inſects*, and other Animals, as can already live without Air, to move alſo without it in our *Vacuum*.

Therefore conſidering with my ſelf what happens to *Infants* and other young Animals in the Womb, and even after they come from thence, if they continue to be wrapt up in the *Secundines*; though as ſoon as they are brought into the free Air they may be preſently killed by being kept from breathing: Conſidering alſo, what I elſewhere relate of the ſlow Expiration of a very young *Kitling* in our *Vacuum*; together with the long want of Reſpiration, which Cuſtome enables ſome *Divers* to endure: Conſidering theſe things, I ſay; though I know, that ſomewhat may be objected to ſhew, that theſe Inſtances are not altogether full to my purpoſe; yet they, among other things, invited me to think, that the leaſt unlikely projects, that occurr'd to my barren Invention, would be theſe that follow.

Firſt, I thought fit to try, Whether the *Seeds* of reſpiring Animals might be either hatched or otherwiſe brought to produce Young ones in our *Vacuum*. For, if that could be compaſſed, I ſhould obtain my end.

Next, in caſe of my failing in the former attempt, and that, which is to be after a few Lines propoſed, I thought fit to try, whether at leaſt I could not bring the *Eggs* of Inſects to hatch or be animated; or *Aurelias* (as they call them) that were already alive, turn according to the courſe of Nature, into *Winged Inſects*, as Flies or Butter-fiſhes: (of which tryals and thoſe of the former ſort, the account properly belongs to another place, where I relate the ſucceſs of theſe and other attempts to produce Plants and Animals in our *Vacuum*.)

But *thirdly*, Conſidering that Nature has ſo ordered it, that *Froggs*, though when they are grown big enough to deſerve that name, they be amphibious Animals endowed with Lungs; yet before they attain to that pitch, they live wholy in the water like Fiſhes; I thought it the moſt expeditious and leſt improbable attempt we could make, to try, Whether or no this Animal, being as a Fiſh brought to live either in our *Vacuum*, or at leaſt in highly rarified Air, would not continue to do ſo, after its Lungs ſhould be perfectly formed. Wherefore though I foreſaw and foretold the difficulty, that would be met with in the proſecution of this Experiment, namely that the Aereal Bubbles, that would be diſcloſed in ſuch ſoft Bodies upon the withdrawing of the preſſure of the ambient would ſo violate the ſlight Texture of thoſe tender Animals, as to hinder them from living long or moving freely; yet I thought it very fit to attempt the Tryal, whereof I find this account among my Adverſaria.

Experiment 1.

We took a good Company of *Tadpoles*,and put them with a convenient quantity of water into a Portable Receiver of a round figure, and obſerved,that at the firſt exuction of the Air they did riſe to the top of the water,though moſt of them ſubſided again, till the next exuction raiſed them.They ſeemed by their active and wrigling motion to be very diſcompoſed.The Receiver being exhauſted,they continued reſtleſs moving all of them in the top of the water,and though ſome of them ſeemed to endeavour to go to the bottom,and dived ſome part of the way, eſpecially with their heads,yet they were immediately boyed up again.Within an hour or a little more they were all moveleſs, and lay floating on the water ; wherefore I opened the Receiver,upon which the Air ruſhed in,and almoſt all of them (which were many) preſently ſunk to the bottom,but none of them recovered to life.

Experiment 2.

A little after theſe,we included a leſſer number of *Tadpoles* in a ſmaller Glaſs,which was alſo exhauſted with the like circumſtances with the former.And when I found the other *Tadpoles* to be dead,I haſted to theſe, which did not,except perhaps one,give any ſign of Life , but upon letting in the Air,theſe having not been long kept from it, ſome few of them did recover,and ſwam up and down lively enough for ſome time; though after a while they alſo dyed.

Experiment 3.

Some years after I repeated the ſame Experiment in a portable Receiver of a convenient kind,and though,after the Exhauſtion was perfected, the Tadpoles did for a while move briskly enough on the top of the water (none of them appearing able to dive or ſwim under water) yet coming to look on them at the end of an hour, they ſeemed to be all of them quite dead,yet continued floating.And though within half an hour after that,I let in the Air upon them,yet all the effect of it was, that the moſt of them immediately ſunk to the bottom, as the reſt of them did a very little while after ; none of them,that I could obſerve, recovering any vital motion.

Experiment 4.

There remains an Experiment, which I often judged as well more hopefull as more noble,if I could procure an opportunity to bring my deſign to a tryal,which I have found it very difficult to do ; nevertheleſs I was able to do it once,though not fully as I deſired , yet not altogether without ſucceſs.

We procured then,and with much adoe,ſome of thoſe odd Inſects,which I elſewhere deſcribe, whereof *Gnats* have by ſome ingenious men been obſerved to be generated about the end of *Auguſt*,or beginning of *September*. Theſe for ſome weeks live all together in the water (as *Tadpoles* do) ſwimming up and down therein,till they are ripe for a tranſmigration into flyes : which it ſelf is ſo great a Rarity in Nature, as makes theſe little Creatures recompence to our Curioſity the trouble,they often give our faces and hands. Suppoſing then that, if I could get ſome of theſe, and include them, being of thoſe Inſects they call *Aquatilia*, and ſo minute as they are, they may live a great while in the Receiver without Air, and in the mean while attain the Period, which, according to natures courſe, is wont to turn them into flyes, which might come forth winged Creatures into a Medium not furniſhed with common Air, as others of their kind enjoy; ſuppoſing, I ſay, that theſe Inſects would afford me ſome information about theſe particulars, having upon much watching met with four or five of them after a ſhower of Rain, that dropt from a houſe into a veſſel laid on purpoſe for it, we included them with ſome of their water into a ſmall Glaſs Receiver, which being very exactly cloſed, we kept in a South-window, where theſe little Creatures continued to ſwim up and down for ſome few dayes without ſeeming to be much incommodated by ſo unuſual an habitation; and at the end of that time, and much about the ſame day, they deveſted the habit they had, whileſt they lived as fiſhes, and appeared with their *Exuvia* or caſt coats under their feet, ſhewing themſelves to be perfect *Gnats*, that ſtood without ſinking upon the ſurface of the water, and diſcovered themſelves to be alive by their motion, when they were excited to it: but I could not perceive them to fly in that thin medium; to which inability, whether the viſcoſity of the water might contribute, I know not; though they lived a pretty while, till hunger or cold deſtroyed them. Some thing in this Experiment may deſerve ſerious Reflections; which I cannot ſpare time to offer at.

A Digreſſive Experiment concerning the Expanſion of Bloud and other Animal Juyces.

For ſome purpoſes, relating partly to Reſpiration, and partly to other Enquiries, I thought fit to endeavour to obtain what information could be procured, of the Conſiſtence and Diſpoſition to expand it ſelf of *Blood* and other Animal Liquors; In purſuance of which the enſuing tryals, among others, were undertaken.

The warm Blood of a Lamb or a Sheep being taken as it was haſtily brought from the Butchers, where the Fibers had been broken to hinder the coagulation, was in a wide mouth'd Glaſs put into a Receiver, made ready for it; and the pump being early ſet on work, the Air was diligently drawn out: but the Operation was not alwaies, eſpecially at firſt, ſo early manifeſt, as the Spirituouſneſs of the Liquor made ſome expect; yet this hindered not but after a long expectation, the more ſubtle parts of the Blood would begin to force their way through the more clammy ones, and ſeem to boyle in large cluſters, ſome as big as great Beans or Nutmeggs; and ſometimes, to the wonder of the by-ſtanding Phyſitians, the Blood was ſo Volatile, and the expanſion ſo vehement, that it boyled over the containing Glaſs; of which, when it was put in, it did not, by our eſtimate, fill above a quarter. Having alſo included ſome *Milk* warm from the Cow in a Cylindrical veſſel of about four or five inches high, though the Operator were induced to pump a great while before any intumeſcence appeared in the milk,yet afterwards,when the external Air was fully withdrawn,the white liquor began to boyle in a way that was not ſo eaſy to deſcribe,as pleaſant to behold : And this it did for a pretty while with ſo much impetuoſity, that it threw up ſeveral parts of it ſelf out of the wide mouthed Glaſs that contained it (and could have contained as much more) though there were not above two or three ounces of the liquor.

A yet greater diſpoſition to intumeſcence we thought we obſerved in the *Gall*,which was but ſuitable to the viſcoſity of the Texture.

Note,that the two foregoing Experiments were made with an Eye caſt upon the inquiry,that I thought might be made ; Whether,and how far the deſtructive operation of our Engin upon the included Animal, might be imputed to this,that upon the withdrawing of the Air, beſides the removal of what the Airs preſence contributes to life,the little Bubbles generated upon the abſence of the Air in the Bloud,juyces,and ſoft parts of the Body,may by their Vaſt number, and their conſpiring diſtenſion, variouſly ſtreighten in ſome places, and ſtretch in others, the Veſſels,eſpecially the ſmaller ones,that convey the Bloud and Nouriſhment ; and ſo by choaking up ſome paſſages,and vitiating the figure of others, diſturb or hinder the due circulation of the Bloud? Not to mention the pains that ſuch diſtenſions may cauſe in ſome Nerves, and membranous parts,which by irritating ſome of them into Convulſions may haſten the death of Animals,and deſtroy them ſooner by occaſion of that irritation,than they would be deſtroyed by the bare abſence or loſs of what the Air is neceſſary to ſupply them with. And to ſhew, how this production of Bubbles reaches even to very minute parts of the Body, I ſhall add on this occaſion (hoping that I have not prevented my ſelf on any other,)what may ſeem ſomewhat ſtrange,what I once obſerved in a *Viper*,furiouſly tortured in our Exhauſted Receiver,namely that it had manifeſtly a conſpicuous Bubble moving to and fro in the wateriſh humour of one of its Eyes.

Another Digreſſive Experiment belonging to the ſame Title.

To ſhew,that not only the Bloud and Liquors,but alſo the other Soft parts, even in cold Animals, have Aerial particles latitant in them ; we took the *Livers* and *Heart* of an *Eele*, as alſo the Head and Body of another fiſh of the ſame kind, cut a ſunder croſſe wayes ſomewhat beneath the heart,and putting them into a Receiver,upon the withdrawing of the Air we perceived, that the Liver did manifeſtly ſwell every way,and that both the upper and lower parts did ſo likewiſe ; and at the place where the diviſion had been made,there came out in each portion of the fiſh divers Bubbles, ſeveral of which ſeemed to come from the *Medulla Spinalis*,or the cavity of the Back-bone,or the adjoyning parts ; and the External Air being let in,both the portions of the Eele preſently ſhrunk,ſome of the skin ſeeming to be grown empty or flaccid in each of them.

The

The XIV. Title.

Of the power of Aſſuefaction to enable Animals to hold out in Air, by Rarefaction made unfit for Reſpiration.

The power of Aſſuefaction *in other Caſes, made me think it very well worth trying what it would do in Reſpiration: And the rather, becauſe I preſumed, it might prove an Experiment of good uſe, if we ſhould diſcover, that by a gradual accuſtomance an Animal may be brought to live, either in a* much thinner *Air, or much longer in the* ſame *Air, than at firſt he could. But in regard that to make ſuch a Tryal perſpicuouſly enough, the opacity of the Bladder made uſe of in the former* Title, *was like to be an Impediment, I deviſed another way to obviate that Inconvenience, which may, I hope, be competently underſtood, by the heedfull peruſal of the following Tryals.*

Experiment 1.

We included in a round Violl with a wide neck, (the whole Glaſs being capable of containing about 8 ounces of Water) a young and ſmall *Mouſe*, and then tyed ſtrongly upon the upper part of the Glaſſes neck a fine thin bladder, out of which the Air had been carefully expreſſed, and then conveyed this Phantaſtical Veſſel into a middle ſized Receiver, in which we alſo placed a Mercurial *Gage* (adjuſted by our elſewhere mentioned ſtandard;) This done, the Air was by degrees pumped out, till it appeared by the Gage, that there remained but a fourth part in the *external* Receiver (as for diſtinctions ſake I call it ;) whereupon the Air in the *internal* Receiver expanding it ſelf, appeared to have blown the Bladder almoſt half full, and the Mouſe ſeeming very ill at eaſe by his Leaping, and otherwiſe endeavouring to paſs out at the neck of his uneaſy Priſon; we did, for fear the over thin Air would diſpatch him, let the Air flow into the external Receiver, whereby the bladder being compreſſed, and the Air in the Violl reduced to its former denſity, the little Animal quickly recovered.

Experiment 2.

A while after, without removing the bladder, the Experiment was repeated, and the Air by the help of the Gage was reduced to its former degree of Rarefaction, and the Mouſe, after ſome fruitleſs endeavours to get out of the Glaſs, was kept in that thin Air for full 4 minutes; at the end of which he appeared ſo ſick, that, to prevent his dying immediately, we removed the External, and took out the Internal Receiver. Whereupon, though he recovered, yet 'twas not without much difficulty, being unable to ſtand any longer upon his feet, and for a great while after continued manifeſtly trembling.

Experiment 3.

But having ſuffered him to reſt a reaſonable ſpace of time, preſuming that aſſuefaction had accuſtomed him to greater hardſhips, we conveyed him again into the external Receiver, and having brought the Air to the former degree of Expanſion, we were able to keep him there for a full quarter of an hour; though the external Receiver did not at all conſiderably leak; as appeared both by the Mercurial Gage, and by the continuing diſtenſion of the Bladder. And 'tis worth noting, That, till near the latter end of the quarter of an hour, not only the Animal did ſcarce at all appear diſtreſſed, remaining ſtill very quiet: but, which is more, whereas, when he was put in, the tremblings formerly mentioned were yet upon him and continued ſo for ſome time; yet afterwards, in ſpight of the Expanſion of the Air he was then in, they left him early enough And when the Internal Receiver was taken out, he did not only recover from his fainting fit ſooner then before; but eſcaped thoſe ſubſequent tremblings we have mentioned.

Experiment 4.

Incouraged by this ſucceſs, after we allowed him ſome time to recollect his ſtrength, we reconveyed him and the odd veſſel, wherein he was included, into the former Receiver, and pumped out the Air, till the Mercury in the Gage was not only drawn down as low as formerly; but near half an Inch lower, that there the Air might be yet further expanded, than hitherto it had been. And though this did at firſt ſeem to diſcompoſe our little Beaſt; yet after a while he grew very quiet, and continued ſo for a full quarter of an hour: when, being deſirous to try what operation a further Rarefaction of the Air would have upon him, we cauſed three Exſuctions more to be made by the Pump, before we diſcovered him to be in manifeſt danger, (at which time the Bladder appeared much fuller then before;) but then we were obliged to let the Air into the outward Receiver; whereupon the Mouſe was more ſpeedily revived then one would have ſuſpected.

And theſe tryals of the Power of Aſſuefaction ſeemed the more conſiderable, becauſe the Air, in which the Mouſe had all this while lived, had been clogged and infected with the excrementitious Effluviums of his Body; for 'twas the ſame all along, we having purpoſely forborn to take off the Bladder, whoſe regular Intumeſcencies and ſhrinkings ſufficiently manifeſted, that the veſſel, whereof 'twas a part, did not leak.

POSTSCRIPT.

Though the ſucceſs of the recited Experiments is very promiſing; yet a ſubſequent Tryal or two, whoſe particularities are ſlipt out of my memory, oblige me, in point of Candour, to declare, that, for further ſatisfaction, the Tryals of the power of Accuſtomance in reference to Air unfit for Reſpiration, ought to be both reiterated, and to be made in differing ſorts of Animals.

The XV. Title.

Some Experiments ſhewing, that Air, become unfit for Reſpiration, may retain its wonted preſſure.

Experiment I.

We took a Mouſe of an ordinary ſize, and having (not without ſome difficulty) conveyed him into an Ovall Glaſs, fitted with a ſomewhat long and conſiderably broad neck, which we had provided, that it might be wide enough to admit a Mouſe in ſpight of his ſtruggling. We conveyed in after him a Mercurial Gage, in which we had diligently obſerved and marked the Station of the Mercury, and which was ſo faſtned to a Wire reaching to the bottom of the Oval Glaſs, that the Gage, remaining in the neck, was not in danger to be broken by the motions of the Mouſe in the Oval part: The upper part of the long neck of the Glaſs was, notwithſtanding the wideneſs of it, hermetically ſealed by the help of a Lamp and a pair of Bellows, that we might be ſure, that the impriſoned Animal, ſhould breath no other Air, then that which filled the Receiver at the time when it was nipped up. This done, the Mouſe was watched from time to time, and though by reaſon of the largeneſs of the Veſſel in compariſon of ſo ſmall an Animal, he ſeemed to me rather drooping then very near death at the end of the ſecond hour; yet coming to look upon him about half an hour after, he was judged by the Spectators quite dead, notwithſtanding our ſhaking of the Veſſel to rouze him up. This made me caſt my eyes upon the Gage, wherein I could not perceive any ſenſible change of the Mercuries Station. But being unwilling to give over the Mouſe without trying what freſh Air would do to recover him, I cauſed the ſealed part of the Glaſs to be broken off, and, notwithſtanding that his continuing to appear dead increaſed the confidence of thoſe that thought him ſo, I obtained after a while ſome faint tokens of life; though I am not ſure, that they would have continued in a Veſſel where the Air was ſo clogged and infected, if it had not been that freſh Air was frequently blown in by a pair of Bellows, whoſe noſe was inſerred into the neck of the Glaſs. This freſh Air ſeemed evidently, though but ſlowly, to revive the gaſping Animal, whom I would not, nor could not conveniently take out of the Glaſs, till he had gained ſtrength enough to make uſe of his Leggs; after which without breaking of the Glaſs (which I was loath to looſe, having then no other of the kind) we took him out and found him quickly able to go up and down. After which ſervice, and another Tryal we had made with him, which belongs not to this place, we ſet him at liberty to ſhift for himſelf.

Experiment 2.

Such an Experiment as the former we made with like ſucceſs upon a ſmall Bird included *with a Gage* in a Receiver holding about a quart of Water. The Bird in about half an hour appeared to be ſick and drooping, and the faintneſs and difficulty of breathing increaſed for about two hours and an half after that, at which time the Animal dyed, the Gage being not ſenſibly altered, unleſs perhaps the Mercury appeared to be impelled up a little thought higher than it was when put in; which yet might well enough proceed from ſome accidental cauſe.

Experiment 3.

To ſatisfie ſome curious perſons; that it is not *want* of *Coldneſs*, but ſomething elſe in the included Air, that makes it deſtroy the Birds that are pent up in it, and by the hot Exhalations that ſteam from their bodies may be ſuppoſed to overwarm it, we made the following Experiment.

In a Glaſs-Viol, capacious enough to hold about 3 quarts of water, we not only included, but for greater accuracy hermetically ſealed up a ſmall Bird, and found, that in a few minutes he began to be ſick and pant; which Symptoms I ſuffered to continue and encreaſe againſt the mind of a learned byſtander, (who thought the Animal would not hold out ſo long,) till they had laſted juſt half an hour: at which time having provided a veſſel of water with *Sal Armoniack* newly put into it, to refrigerat it, (according to the way I elſewhere publiſhed;) and the liquor thus made exceeding cold, ſomewhat to the wonder of thoſe that felt it; the Viol with the ſick Bird was immerſed in it, and kept there in that condition for 6 minutes; and yet it did not appear, in the judgment of the By-ſtanders, that the great refrigeration; that muſt be this way procured to the impriſoned Air, did ſenſibly revive or refreſh the drooping Animal, who manifeſtly continued to pant exceedingly as before, and, as ſome affirmed, more; So that this remedy proving ineffectual, the viol was removed out of the water, and the Bird ſometime after did, as I foretold, make many ſtrains to Vomit (though ſhe brought up little) followed by Evacuations downward, before ſhe quite expired, which ſhe did within a minute or two of a juſt hour, after the beginning of her impriſonment.

If I had been able (which I was not) to procure more Birds, I would willingly have proſecuted this Experiment by ſeveral other not unhopefull tryals; which for want of Subjects I was fain to leave only deſigned.

The XVI. Title.

Of the uſe of the Air to elevate the Steams of Bodies.

In the Digreſſion about Reſpiration annext to the 41th of our *Phyſico-mechanical* Experiments formerly publiſhed, it is propoſed as one of the conſiderable uſes of the Air in Reſpiration, that, being drawn into the Lungs, it ſerves to carry off with it, when 'tis breathed out again, the Recrementitious ſteams that are ſeparated from the maſs of Blood in its Paſſage through the Lungs: from which fuliginous Excrements if the Blood were not continually freed by the help of the Air, after nature had been accuſtomed to that way of diſcharging them, their ſtay in the body might have very great and deſtructive Operations on it.

For the Illuſtration of this uſe of the Air, I ſhall now ſubjoyne the following Experiment.

We made by diſtillation a blood-red Liquor, which chiefly conſiſted of ſuch Saline and Spirituous particles, as may be obtained from the Maſs of Blood in humane Bodies; This Liquor is of ſuch a Nature, that if a Glaſs Viol, about half filled with it, be kept well ſtop'd, the red liquor will reſt as quietly as any ordinary one, without ſending up any ſmoak or viſible Exhalation; But if the Viol be unſtopped ſo, that the external Air be permitted to come in, and touch the Surface of the Liquor, within a quarter of a minute or leſs, there will, upon this Contact, be elevated a copious white ſmoak, which will not only fill the upper part of the Glaſs, but plentifully paſs out into the open Air, till the Viol be again ſtopped.

My purpoſe in this Tract to forbeare ſidings in Controverſies, keeps me from taking notice of the ſpeculations ſuggeſted by ſome of the Phœnomena of this Liquor; which yet I thought I might lawfully mention, as far as I have done it, becauſe it but adventures upon giving one of the Uſes rather of the Air, then immediately of Reſpiration it ſelf; and is brought but to illuſtrate what I have not found denied by any, though conſidered by very few; namely, the office of the Air to carry off in Expiration the fuliginous ſteams of the Lungs. For, in our Experiment we manifeſtly ſee, that the very Contact of the Air may give the Corpuſcles

puſcles of moiſt bodies a peculiar Volatility, or facility to emerge in the form of Steams. I know, there are ſome Corroſive Spirits, as in Nitre and Salt, ſimple, or compounded of them, that, when they are very ſtrong, emit for a while manifeſt fumes; but the difference of thoſe Liquors, and their inferiority to our red Spirit, in the Capacity of ſmoaking Liquors, might eaſily enough be manifeſted, if it were judged proper in this place, where it may ſuffice, to take notice of theſe two things: The *one* is, That when the Viol has lain ſtopped and quiet a competent time, the upper half of it will appear deſtitute of fumes, of which the Air, it ſeems, will imbibe, and conſtantly retain *but* a certain moderate quantity, which may give ſome light towards the Reaſon, Why the ſame Air, which will be quite clogged with ſteams, will not long ſerve for Reſpiration, which requires frequent ſupplies of freſh Air: The *other* is, That if the unſtop'd Viol were placed in our *Vacuum*, it would not emit any viſible ſteams at all, nor ſo much as to appear in the upper part of the Glaſs it ſelf that held the Liquor; whereas, when the Air was by degrees reſtored at the ſtopcock, without moving the Receiver it ſelf, to avoid injuring its cloſeneſs, the returning Air would preſently raiſe the fumes, firſt into the vacant part of the Viol, whence they would aſcend into the Capacity of the Receiver; and likewiſe, when the Air, that was requiſite to ſupport them, was pumped out, they alſo accompanied it, as their unpleaſant ſmell evinced, and the red Spirit, though it remained unſtopped, emitted no more fumes till the new Air was let in.

One may compare with this Liquor another Smoaking one, mentioned in the 29th of the firſt publiſhed Pneumatical Experiments, where an Experiment is related of it, that has ſomething in common with *this*, and may ſo far ſerve to confirm what is now delivered, as this alſo has ſome things additional to *that*: Beſides that that Liquor being made with Ingredients Corroſive, and of a bad name among Chymiſts themſelves, the fumes, that proceed from it, may fright many from daring to meddle with it: whereas this our red Spirit has been found potently medicinal for ſome diſtempers of the Lungs by a Dr. *of Phyſick*, whom I deſired to try it. The other Phœnomena of this Liquor I ſhall not ſtay to deſcribe as not belonging to this place, and the Liquor it ſelf with very little variation I have in the *Hiſtory of Colours* communicated.

The XVII. Title.

Of the long continuance of a Slow-worm *and a* Leech *alive in the Vacuum made by our Engin.*

In the often cited digreſſion about Reſpiration, there is mention made of the great Vivaciouſneſs of *Houſe-Snails* as they call them, and how little operation the withdrawing of the Air had upon them in compariſon of what 'tis wont to have on other Animals. I ſhall now add by way of Confirmation, that I made Tryal upon ordinary *white Snails without ſhells*, whereof two of differing ſizes (the biggeſt about an Inch and a half, and the other about an Inch in length) were included in a ſmall portable Receiver, which being carefully exhauſted, and ſecured againſt the Return of the Air, was attentively conſidered by me, preſently after 'twas removed from the Engine; whereby it was eaſy to diſcern, that both the Snails thruſt out and retracted their Horns (as they are commonly called) at pleaſure, though their Bodies had in the ſofter places pretty ſtore of newly generated Bubbles ſticking to them: but though they did not looſe their motion near ſo ſoon, as other Animals were in our *Vacuum* wont to do; yet coming to look on them after ſome hours, they appeared moveleſs and very tumid, and at the end of 12 hours the inward parts of their bodies ſeemed to be almoſt vaniſhed, and they ſeemed to be but a couple of ſmall full-blown Bladders; and on the letting in of the Air they immediately ſo ſhrunk, as if the Bladders having been prick'd, the receding Air had left behind it nothing but skins; nor did either of the Snails afterwards, though kept many hours, give any ſigns of life.

Upon a ſuppoſition that the cold, and clammy Conſtitution of Snails might be a main cauſe of their being able to endure the abſence of the Air ſo well, I thought it worth Tryal, whether *Efts* and *Leeches* might not yet be more able to continue in our Vacuum then a Snail; and accordingly ſome Experiments were made perſuant to that Curioſity; the moſt fully regiſtred whereof are theſe that follow.

Experiment I.

We included in a Receiver, whoſe Globular part was about the bigneſs of a large Orange, one of that ſort of Animals, that they vulgarly call *Efts*: having withdrawn, but not ſollicitouſly, the Air, and ſecured the veſſel againſt the unpermitted return of it, we kept him there about 48 hours, during all which time he continued alive, but appeared ſomewhat ſwelled in his belly; his under-chap moving the very firſt night, but not the day and night following. By opening the Receiver at length under water, we perceived, that about half the Air had been drawn out. As ſoon as the water was impelled into the Glaſs, the Animal, that was before dull and torpid, ſeemed, by very nimble and extravagant motions, to be ſtrangely revived.

Experiment 2.

We took a *Leech*, that was of a moderate bigneſs, or ſomewhat ſhort of it, and having included it together with ſome water in a portable Receiver, that was gueſſed to be capable of holding about 10 or 12 ounces of that liquor; the Air was pumped out after the uſual manner, and the Receiver being removed to a lightſome place, we obſerved, as we expected, that, the Leech keeping her ſelf under water, there emerged from divers parts of her Body ſtore of Bubbles, ſome of them in a diſperſed way, but others in Rows or Files, if I may ſo ſpeak, that ſeemed to come from determinate points. Though this Production of Bubbles laſted a pretty while, yet the Leech did not ſeem to be very much diſcompoſed by her preſent condition. This done we diſpoſed of the Receiver, which was well ſecured from the ingreſs of the outward Air, into a quiet place, where we daily viſited it once at leaſt, or oftner, as there was occaſion;

and found the Leech ſomewhat faſtened by her tail to that part of the Glaſs that was under water, and ſometimes wandring about that part, which was quite above water; and ſtill, when we endeavoured to excite her, ſhe quickly manifeſted her ſelf to be alive: And indeed (which will be thought ſtrange) appeared ſo lively after the full expiration of five natural days, that expecting ſomething might have happened to the Receiver, and thereupon reſolving to try how ſtanch it had continued, I opened it under water, by which means the outward Air impelled in ſo much of that Liquor, that I was ſatisfied, the Receiver was immediately before as well exhauſted, as others are wont to be in our Pneumatical Experiments.

The XVIII. Title.

Of what happened to ſome Creeping *Inſects in our* Vacuum.

Notwithſtanding the great Variety of Reptills, that Nature does almoſt every where produce; yet the inconvenient time and place, wherein the following Tryals were made, ſupplyed me with ſo few, that about theſe Animals I find among my Adverſaria no more then the enſuing Notes.

Experiment 1.

We took five or ſix *Caterpillars* of the ſame ſort; but I could not tell to what ultimate ſpecies the Writers about Inſects referred them. Theſe being put into a ſeparable Receiver of a moderate ſize, had the Air drawn away from them, and carefully kept from returning. But notwithſtanding this deprivation of Air, I found them, about an hour after, moving to and fro in the Receiver; and even above two hours after that, I could by ſhaking the Veſſel, excite in them ſome motions, that I did not ſuſpect to be Convulſive. But looking upon them again ſome time before I was to go to bed (which may be was about 10 hours after they were firſt included) they ſeemed to be quite dead, and, though the Air were forthwith reſtored to them, they continued to appear ſo, till I went to Bed; yet, for Reaſons elſewhere expreſſed, I thought fit to try, whether time might not at length recover them, and leaving them all night in the Receiver, I found the next day, that 3, if not 4 of them, were perfectly alive.

Experiment 2.

We took from an hedge a branch, that had a large Cobwebb of Caterpillars in it, and having divided it into two parts, we put them into like Receivers, and in one of them ſhut up the Caterpillars together with the Air, which from the other was exhauſted. The event was, That in that which had the Air, the little and difficultly viſible Inſects, after a ſmall time, appeared to move up and down as before, and ſo continued to do for a day or two; after which, other occaſions made the Experiment to be neglected: whereas that Glaſs whence the Air had been drawn out, and continued kept out, ſhewed after a very little while no motion that we could perceive. But to try, Whether Caterpillars may continue ſo far alive in our *Vacuum* all the winter, as the next Spring or Summer to proceed in the tranſmigration to a Butterfly, is a Tryal that we have but begun, and therefore muſt not pretend to ſay any thing about its Event.

The XIX. Title.

Of the Phænomena ſuggeſted by Winged Inſects *in our Vacuum.*

When our Phyſico-mechanical Experiments were diſpatched to the Preſs, the inconvenient ſeaſon of the year, and the difficulty of making the Receivers, I then employed, to keep out the Air for any long time, hindered me from then publiſhing above a Tryal or two of what would happen to *Winged Inſects* in our Vacuum. But afterwards being provided of more commodious Veſſells, I thought fit at ſeveral times to repair that Omiſſion by various Attempts, where of the chief enſue.

Experiment 1.

Novemb. 12th *about* 8 *a Clock at night.*

There were taken 4 middle-ſiz'd *Fleſh-flies*, which having their heads cut off were incloſed in a Portable Receiver, furniſhed with a pretty large Pipe and a Bubble at the end. As ſoon as the Receiver was Exhauſted, thoſe Flies loſt their motion (which was not briſk before;) an hour or two after, I approached them to the fire, which reſtored not their Motion to them (but as to one of them I ſuſpected it had a Languid motion for a while;) wherefore I let in the Air upon them, after which in a very ſhort time (though not immediately) they began one after another to move their Leggs, and one or two of them to walk; and having kept them all night in a warm place, when I ſent one the next morning to try, if they would manifeſt any motion, he told me, that for a while they did, though, when I afterward riſe my ſelf, I could not perceive any motion in them.

Experiment 2.

Sept. 11th.

About Noon we cloſed up divers *ordinary Flies*, and a *Bee* or *Waſp*; all which, when the Air was fully withdrawn, lay as dead, ſave that for a very few minutes ſome of them had Convulſive motions in their Leggs. They continued in this ſtate 48 hours, after which the Air was let in upon them, and *that* not producing any ſigns of Life in them, they were laid in the Meridian Sun, but not any of them ſeem'd in any degree to recover.

Experiment 3.

Dec.the 11th.

We put a great *Fleſh-fly* into a very ſmall portable Receiver, where at firſt it appeared to be very briſk and lively, but as ſoon as the Air was drawn out, fell on his back and ſeemed to have Convulſive motions in her feet and *Proboſcis*; from whence ſhe preſently recover'd upon the letting in of the Air; which being drawn out again, ſhe lay as dead: but a while after, (within a quarter, or half an hour) I perceived, that upon ſhaking the Receiver, ſhe ſtirred up and down, (but faintly.) This was done pretty late yeſter-night, ſince whence I had not occaſion to look on the Glaſs, till this night after Supper, when I found the fly not (whileſt I ſtayed to endea-

vour

vour it) to be recovered either by warmth, or letting in the Air. A while after this Note was written, this Fly recovered; and being next morning ſealed up again in that Glaſs, and kept 48 hours, though over the Chimney, died for good and all,

Experiment 4.

We took a large *Graſs-hopper*, whoſe Body, beſides the Horns and Limbs, was about an Inch in length, and of a great thickneſs in Proportion to that length: this we conveyed into a Portable Receiver of an Oval form, and capable of holding (by our gueſs) about a Pint of water and more, and having afterwards pumped out the Air, till by the Gage it appeared to have been pretty well drawn out, we took care, no Air ſhould reenter to diſturb the Experiment. The ſucceſs whereof was this: Firſt, Though, before the Exhauſtion of the Air was begun, the Graſhopper was ſtirring, and lively, and continued ſo for a while after the beginning of the Operation; yet when the Air began to be conſiderably rarified, he appeared to be very ill at eaſe, and ſeemed to ſweat out of the Abdomen many little drops of Liquor, which being united trickled down the Glaſs like a little ſtream, which made at the Bottom a ſmall Pool of clear Liquor, amounting to near a quarter of a Spoonful, and by that time the Receiver was ready to be taken off, the Graſhopper was fallen upon his back, and lay as dead. Secondly, Though having a little after laid the Glaſs in a South window, on which the Sun then ſhone, I perceived ſome ſlow motions in the Thorax, as if he ſtrained to fetch breath; yet I was not ſure they were not Convulſive motions, and what ever they were, they laſted but a while, and then the Animal appeared to be quite dead, and to continue ſo for three hours from the removal of the Receiver. Thirdly, that time being expired, the Glaſs was opened and the Air let in upon him, notwithſtanding which there appeared no ſign at all of Life; but imagining there might be ſome time requiſite to recover him out of ſo deep a ſwoon, I let the Glaſs reſt in a convenient Poſture, that the water that came from him might not endanger him, for a quarter or half an hour, and though I then perceived no ſigns of Life, yet being deſirous to perſue the Tryal yet further, I cauſed him to be carried into a Sunſhiny place, where the Beams of a declining Sun preſently began to make him ſtir his Limbs, and in a ſhort time brought him perfectly to Life again.

Experiment 5.

April the 15th.

We took one of thoſe *ſhining Beetles* they call *Roſe-Flies*, and having included it in a very ſmall round Receiver, which we exhauſted, and though he that attended the Engine, affirmed, it ſtrugled much whileſt the Air was withdrawing, yet preſently after, I could perceive but little motion (and part of that ſeemed almoſt Convulſive) and afterward going abroad, and not returning to look on the Glaſs till about 6 hours after, the Fly ſeemed quite dead, and diſcovered not any motion upon that of the Glaſs. And within about an hour after, though I let the Air ruſh in; yet no ſign of Life enſued,neither immediately,nor for a pretty while after. So that ſuſpecting the fly to be really dead, and yet not reſolutely concluding it, though I would then wait no longer, yet three or four hours after (*viz.* about 10 of the Clock at night) I returned to the Receiver, and found the *Beetle* lively enough. Whereupon I cauſed the Glaſs to be again exhauſted,and ſecured from the Ingreſs of the Air,during which time the Animal ſeemed to be much diſquieted by what was done to it, but did not looſe its motion before I went to bed,which was ſoon after.

Experiment 6.

About *Butterflies* I remember I made ſeveral Tryals, moſt of which chanced to be loſt; but thus much I very well remember, that having obſerved them not only to live but to move longer then was expected, I choſe to include divers of them in Receivers ſomewhat large,eſpecially that I might ſee,whether in ſo thin a Medium ſome or other of them, by the help of their large wings,would be able to fly. But though, whileſt the Air continued in the Glaſſes, they flew actively as well as freely up and down; and though after the Exhauſtion of the Air,they continued to live and were not moveleſs; nay though at the bottom of the Receiver they would even move their wings and a little flutter, yet I could not perceive any of them to fly,by which I mean, perform any progreſſive motion ſupported by the Medium only. And by frequently inverting the Receiver (which I took care ſhould be pretty long to let them fall from one extream to the other,)they would fall like dead Animals without diſplaying their wings, though juſt as they came to touch the Bottom,ſome of them would ſometimes ſeem to make ſome uſe of them, but not enough to ſuſtain themſelves,or to keep their falls from being rude enough.

The XX. Title.

Of the neceſſity of Air to the motion of ſuch ſmall Creatures, as Ants *and even* Mites *themſelves.*

In the Experiments hitherto mentioned,the Animals,on which the Tryals have been made,were divers of them of a moderate Bulk; and others of them, though ſmall,yet not of the leaſt ſizes that Nature afforded us. Wherefore I thought fit to annex the following Experiments, wherein I deſigned to examine,Whether even thoſe minute ſorts of Animals, whoſe bulk is thought the moſt contemptible, have not,as well as the greater,need of the Air, if not to make them live, yet at leaſt to enable them to move.

A pretty number of *Ants* were included in a ſmall Portable Receiver exhauſted yeſterday about noon: Between 6 and 7 in the Afternoon they ſeemed to be all quite dead,and the rather,becauſe,though they were very lively juſt before they were ſealed up,running briskly up and down the Bubble they were in; yet they grew almoſt moveleſs as ſoon as the Air was exhauſted; and a little while after appeared more ſo: though I then ſuſpected more then I ſince did, that they were much inconvenienced by ſome ſmall glutinous ſubſtance that ſeemed to have got into the ſmall Receiver from the Vapours of the Cement. When I looked on them at the the time lately mentioned, I opened the Glaſs, whereupon the Air ruſhed in; but no ſign of Life appeared for a great while in any of the *Ants*: but looking upon them this morning about 9 a Clock, I found many of them alive and moving to and fro.

It is ſaid by Naturaliſts upon the Authority of Ariſtotle,*that the Animal, the* Greeks *call* ἄκαρι,*is the minuteſt of Living Creatures. But thoſe of this ſort being very hard, if at all,to be met with here. I thought fit to make ſome Experiments upon the leaſt of the Terreſtrial Animals I could procure, and try, whether or no* Mites *themſelves,which are reputed but* Living Points, *and not to be taken notice of by the naked Eye to be living,but by motions which even an attentive one can ſcarce diſcover,ſtand in need of the Air; eſpecially becauſe, in caſe they do, it may ſuggeſt to us ſome odd Reflections upon the ſtrange ſubtlety and minuteneſs of the Aerial particles,which muſt be capable of flowing in and paſſing out at the inviſible and almoſt in-imaginable ſmall pores and other cavities of the parts of an Animal,whoſe entire body is reputed but a* Phyſical *point.*

We conveyed then a pretty number of *Mites*,together with the mouldy Cheeſe,they were bred in to nouriſh them,into 3 or 4 Portable Receivers (which were all of them very ſmall,) not much differing in ſize. From all of theſe,ſave one,we withdrew the Air; and then, making uſe of our peculiar contrivance to hinder its return,we took them one after another from the Engin,and laid them by,for further obſervation. That *one*, which I took notice that we had reſerved, and in which, to obſerve the difference,we thought fit to leave the Air,was ſealed at a Lamp-furnace after the uſual manner of nipping up Glaſſes there. This done,there remained nothing but to obſerve the Event of our Tryals, which afforded us the enſuing *Phœnomena*;

1. Thoſe Mites,that were incloſed in the ſmall Glaſs that never came near the Engin,continued alive and able to walk up and down for above a full week,after they had been put in,and poſſibly would have continued much longer,if the Glaſs had not been accidentally broken,

2. As ſoon as ever one of the Receivers was removed from the Engin, I looked with great attention upon it; and though juſt before the withdrawing of the Air the *Mites* were ſeen to move up and down in it; yet within a few minutes after the Receiver was applyed to the Engin, I could diſcern in them no Life at all, nor was any perceived by ſome younger Eyes then mine,whereunto I expoſed them. Nay by the help of a double Convex-glaſs (that was ſo ſet in a frame as to ſerve me as a Microſcope on ſuch occaſions) I was not able to ſee any of them ſtir up and down. Nor was any motion taken notice of in the other ſmall Receiver of like bigneſs and ſhape with mine,by them that had exhauſted it of Air. And my occaſions not permitting me to attend the obſervation any longer in the place where 'twas made,I took the Receiver, I had ſo attentively conſider'd my ſelf, along with me in the Coach, and having occaſion to make ſome ſtay about an hour after, I looked upon it attentively again,but could not perceive any of the *Mites* to ſtirr; and the like unſucceſsfull obſervation I made when I had a conveniency 2

or 3 hours after that. And the place I did it in being one, where I thought my ſelf as it were at home, I firſt let in the Air, to try if the Mites were not quite dead, and though neither upon its ruſhing in, nor during my ſtay there, I could perceive any of them to ſtir; yet I left the Receiver unſtopt as it was in the Window, upon a ſuſpition that the Air might not be able to produce its operation upon them in a ſhort time.

3. And therefore paſſing by the ſame place about 2 or 3 dayes after, I called in to look upon my Receiver, and found a number of my little Animals revived, as an attentive Eye might eaſily perceive by the motion of certain little white ſpects, when it was helped to obſerve it by little marks, I made on the outſide of the Glaſs (which was purpoſely choſen thinn and clear) near this or that Mite, with a Diamond; by the approach to, or Receſs from which Marks, the progreſſive motion became (perhaps within a minute) plainly diſcoverable, eſpecially if we uſed the following Expedient, (which I found the beſt of thoſe I try'd,) namely, That, when the Eye perceived little white ſpecks that looked like Mites, the Receiver ſhould be ſo turned and returned, that the bellies and feet of thoſe little Creatures were uppermoſt, notwithſtanding which they would not eaſily drop down, but continue their motion; which ſpecks being made upon the Concave ſurface of the thin Glaſs it ſelf (to which you may approach your Eye as much as you pleaſe) are thereby rendred much more eaſily viſible. But, this being only intimated upon the By, I proceed to take notice, that in the newly mentioned Receiver the Mites did, by ſtirring up and down, continue to appear alive for 2 or 3 dayes after, if not longer. I ſhould not, I confeſs, have thought it ridiculous to ſuſpect, that the Mites, which at firſt loſt their motion, did at laſt really dye, and that thoſe, I after ſaw ſtirring up and down, were others newly generated in the included mouldy Cheeſe: But I was not apt to think this ſuſpicion probable; not only becauſe of the extream difficulty of making any living Creature to be generated in *Vacuo Boyliano*, but becauſe it did not ſeem agreeable to what I elſewhere noted about the way and time of the Propagation of Mites, whoſe Eggs I have divers times obſerved with pleaſure, that at a ſeaſon of the year, that was not favourable (for theſe things happened in a cold *March*,) newly generated Mites ſhould in 2 or 3 dayes grow up to their juſt bigneſs, which ſeveral of thoſe, we obſerved, ſeemed to have attained.

4. But becauſe it doth not by the third *Phænomenon* appear, Whether or no, in caſe our Mites had been kept in a moveleſs ſtate for a much conſiderabler time then 3 or 4 hours, they would have been recoverable by the admiſſion of the Air; I ſhall add, to ſatisfy that doubt, That one of the Portable Receivers above-mentioned, being exhauſted and carefully ſecured from the regreſs of the Air, was kept from Munday morning to Thurſday morning: after all which time, our attentive Eyes being unable to diſcover any ſigns of Life among the included Mites, the Air was let in upon them, and, after no long time, had ſuch an operation upon them, that both I and others could plainly ſee them creep up and down in the Glaſſes again.